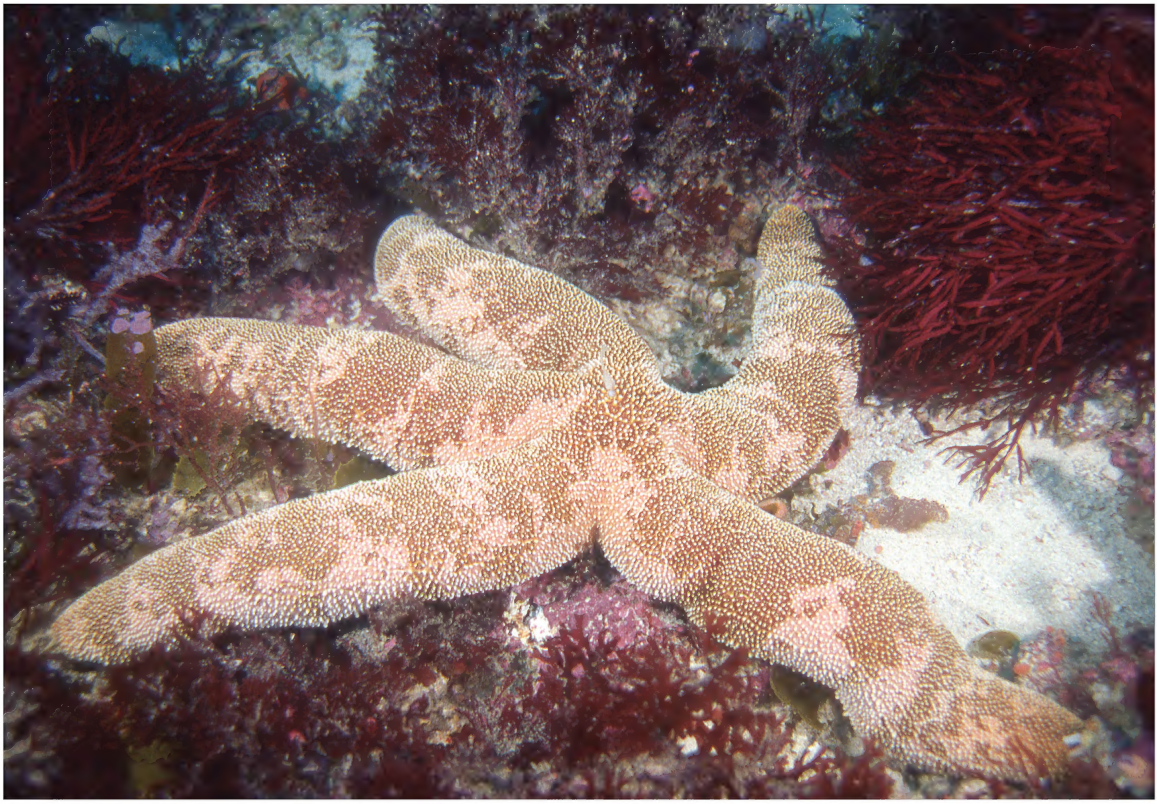
THE WESTERN AUSTRALIAN

NATURALIST

Vol. 32: No. 2, 28 September 2021



Thromidia brycei, a seastar from the Houtman Abrolhos Islands, named by Loisette Marsh after Clay Bryce.

Photo: WA Museum

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PP 6358 23/00015
ISSN 0726 9609

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Typeset and printed in Western Australia

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2021 Serventy Memorial Lecture
20 April 2021

Introduction

The Serventy Memorial Lecture is held every year in honour of the contribution made by the Serventy family (Dominic, Vincent and his wife Carol, and Lucy) to many aspects of natural history in Australia. The WA Naturalists Club was founded by Dom Serventy in 1924 and in 1947 he inaugurated the club's journal, The Western Australian Naturalist. The Serventy family has been an inspiration to members of the Club over many generations. The Serventy Memorial Lecture raises money to support young people studying the natural environment.

Mandy Bamford, a past president of the WA Naturalists' Club, introduced the audience to the contributions of the Serventy family to the study of natural history in WA and Australia. The present president Shashi Sharma, spoke about his hopes for a major celebration of the Club's centenary in 2024. Then Club patron Lyn Beazley introduced Kerry Sanderson as the new co-patron of the Club. Finally, Kerry Sanderson introduced the speaker, the well-known horticulturalist, gardener and broadcaster, Sabrina Hahn (Fig. 1).

Elaine Davison

Figure 1. Left to right: Mandy Bamford, past president of the WA Naturalists' Club; Sabrina Hahn, Serventy Memorial Lecturer; Kerry Sanderson and Lyn Beazley, co-patrons; Shashi Sharma, president. Photo: Jolanda Keeble.

Urban gardens – creating corridors of habitat

Sabrina Hahn

What a privilege to live in WA with its exceptionally diverse flora and fauna! Our state has been geologically stable for aeons, allowing plant communities to form without catastrophic events such as ice ages or volcanic activity. However, this stability has resulted in highly leached, impoverished hydrophobic soils which are low in phosphorus. Such conditions are challenging for crop plants, but the native plants have thrived, resulting in such diversity that the southwest is recognised as a biodiversity hotspot. These plants have developed unusual symbiotic relationships with the soil microflora which enables them to extract phosphorus and other minerals from these nutrient deficient soils. And these plant communities work together to share their limited resources. But these communities are under threat, and it is our responsibility to halt the destruction now, by protecting and preserving what is left, and restoring the structure and complexity of this unique ecosystem.

What are the main challenges?

Just look at WA now, and think of what it must have been like before colonisation.

On the broad scale there is fragmentation of habitats, widespread clearing for agriculture resulting in salinisation, and increased frequency and intensity of fires. We have introduced pathogens such as *Phytophthora*, and numerous herbaceous and woody weeds. And climate change is resulting in declining rainfall and higher temperatures.

On the local scale 'landscraping' to remove all trace of native plants appears to be essential for all new housing developments or urban infill. Smaller blocks covered with hard surfaces result in urban heat islands, whilst changes to drainage patterns affect nearby reserves and other plant communities in the neighbourhood.

There is a lack of environmental protection; even though laws exist, they are not necessarily implemented or are overridden in the name of development. Also, there is a lack of funding and lack of curiosity for what may appear to be local or mundane issues.

Many people do not care about these challenges because they do not know that they live in such a unique environment. They may be unfamiliar with native plants and animals and the complexity of the natural world. Children no longer learn about natural history in schools and have little first-hand experience of the inter-relationships between plants, birds, insects, spiders and all of the other organisms around them.

Looking for solutions

We need to take children and their parents back into nature, and community groups such as the WA Naturalists' Club, have an important role to encourage people discover the great outdoors. But it is not just about being observant, it is also about creating habitats for local wildlife in our gardens and neighbourhoods, in our region and in the state.

The urban dweller

There must be more to urban gardens than roses, palm trees and Astroturf, especially if it is to benefit the local wildlife. Landscape design needs to focus more on creating whole plant communities which will support native bird and insect populations. This means having a good knowledge of our local plants so we can provide the habitat which will invite species in. There needs to be diverse planting schemes of native plants, using plants of different height and structure to provide layers of habitat, for protection and food. Trees are important for perching and nesting, spikey shrubs for roosting and protection, and ground covers for foraging. There needs to be a source of nectar and pollen all year round as well as leaf litter and mulch to encourage invertebrates. Water is important too for wildlife, placed both high and low in the garden. These principles are appropriate for home gardens, as well as in public open spaces managed by local and state government. Focussing on native plants creates habitat where local wildlife thrives and of course, as these have evolved locally, they are easier to maintain in the local climate. Maybe it is time to encourage some 'guerrilla gardening' by infiltrating appropriate native plants into verges or other potentially `unproductive` spaces (Fig. 2).

But there is more to gardens than just growing appropriate native plants. How often do we use chemicals to eradicate unwanted pests? Yet even the most organic formulations have knock-on effects on non-target species, for example the poison in rat baits can

Figure 2. Are you a guerrilla gardener? Image: Jake Bamford - Dapper Cranium Studios.

end up affecting local populations of Boobook Owls. Using no pesticides allows an ecosystem to develop, where predators, such as spiders, feed on insects and insectivorous birds feed on the spiders. By being observant, we can watch this food web develop.

Local councils have an essential role in providing habitat for wildlife in our neighbourhoods. Smaller blocks make street trees even more important, and they don't have to be jacarandas. Planting climate-appropriate trees for increased canopy cover helps to mitigate the urban heat island effect, and there are many native trees which are suitable, although they appear to be more widely used in eastern Australia than locally. Reserves and parks are important too as they provide a continuum to the potential habitat in home gardens and street trees. Reserves also encourage kids into the great outdoors, where nature stimulates their natural curiosity, whether they are looking at a lumbering beetle or watching honey eaters feed on a banksia. Watching what is happening is the first stage in wanting to know how and why.

On a broader scale

Although there are many challenges, there are also opportunities to make the most of what we have, and we need to be proactive at a state government level in ensuring we preserve what remains of our unique environment.

The proposed Yule Brook Regional Park is one example. This would connect the Lesmurdie Falls National Park with the Greater Brixton Street Wetlands, several small reserves, and the Canning River Regional Park. It would provide an ecological corridor from the Darling Scarp across the eastern Swan Coastal Plain to the river. The proposed park would include areas of high conservation value, sites for active and passive recreation and has important indigenous cultural heritage. It would also be easier to control weeds and vermin in a large area than in small, isolated reserves. It would be a winning strategy for the environment, and people in the eastern suburbs.

Issues relating to drainage are a headache for developers as well as for the environment. Engineering solutions may result in raising or lowering water tables in nearby reserves, affecting the survival of native vegetation and the organisms which depend on healthy plant communities. In a drying climate we should treat rainfall and runoff as a valuable resource.

Often we don`t recognise the uniqueness of what we have until it is too late. This is where last ditch efforts such as breeding programs for endangered animals and seed banks for endangered or rare flora are so important. We need to ensure there is a combination of both in-situ (conserving species and communities) and ex-situ conservation (such as collecting seed from plants which may show disease tolerance). But it is far better if we act to sustain and conserve communities before such conservation measures are needed.

It is easy to forget we live in such a special environment and just take it for granted. We can see the value placed on it by others who visit WA to admire the wildflowers or participate in some form of nature-based tourism. We need to see our back yard through their eyes, and ensure it is preserved and enhanced through whatever means we have available.

The occurrence of the frog *Crinia remota* in the northern Kimberley

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Abstract

The occurrence of the myobatrachid frog species *Crinia remota* (Remote Froglet) is recorded for the first time in Western Australia in the northern Kimberley at Mitchell Plateau. The species was originally detected owing to its distinctive male advertising call and further corroborated by genetic analyses. The occurrence of *C. remota* and other small-bodied frogs in the northern Kimberley may be due to recent climate change isolating them from other areas of the Australian Monsoon Tropics to the east.

Introduction

The Kimberley region of Western Australia hosts the highest diversity of frogs in the state, with over 40 species currently recognised (Tyler & Doughty 2009; Doughty 2011). There are 13 species that are endemic to the Kimberley, with the distribution of most of the other species extending to the Top End of the Northern Territory. Some Kimberley species extend across northern Australia as far as the eastern states, although many of these populations are likely to be renamed based on increasingly sophisticated genetic analyses (e.g. Donnellan *et al.* 2021).

Here, I report on the occurrence of the myobatrachid species *Crinia remota* (Tyler & Parker, 1974) in the northern Kimberley region at the Mitchell Plateau. This species is currently known from the type locality of New Guinea (hence the specific name "remota"), northern Queensland and the Top End of the Northern Territory (Fig. 1). Although similar in appearance to the sympatric and widespread *Crinia bilingua* (Martin, Tyler & Davies, 1980), the species was initially detected at the Mitchell Plateau based on its distinctive male mating call. All specimens examined are in the herpetology collection of the Western Australian Museum (WAM).

Observations

On 24 January 2010, during a wet season survey at the Mitchell Plateau, nocturnal frog sampling was undertaken in the vicinity of Little Mertens Falls. In the early evening (~1800 h), a dense chorus of *Crinia bilingua* was heard calling from a flooded area in a woodland adjacent to a sandstone platform. The location was approximately 1 km upstream of the falls at 14.8197°S, 125.7194°E (Fig. 1).

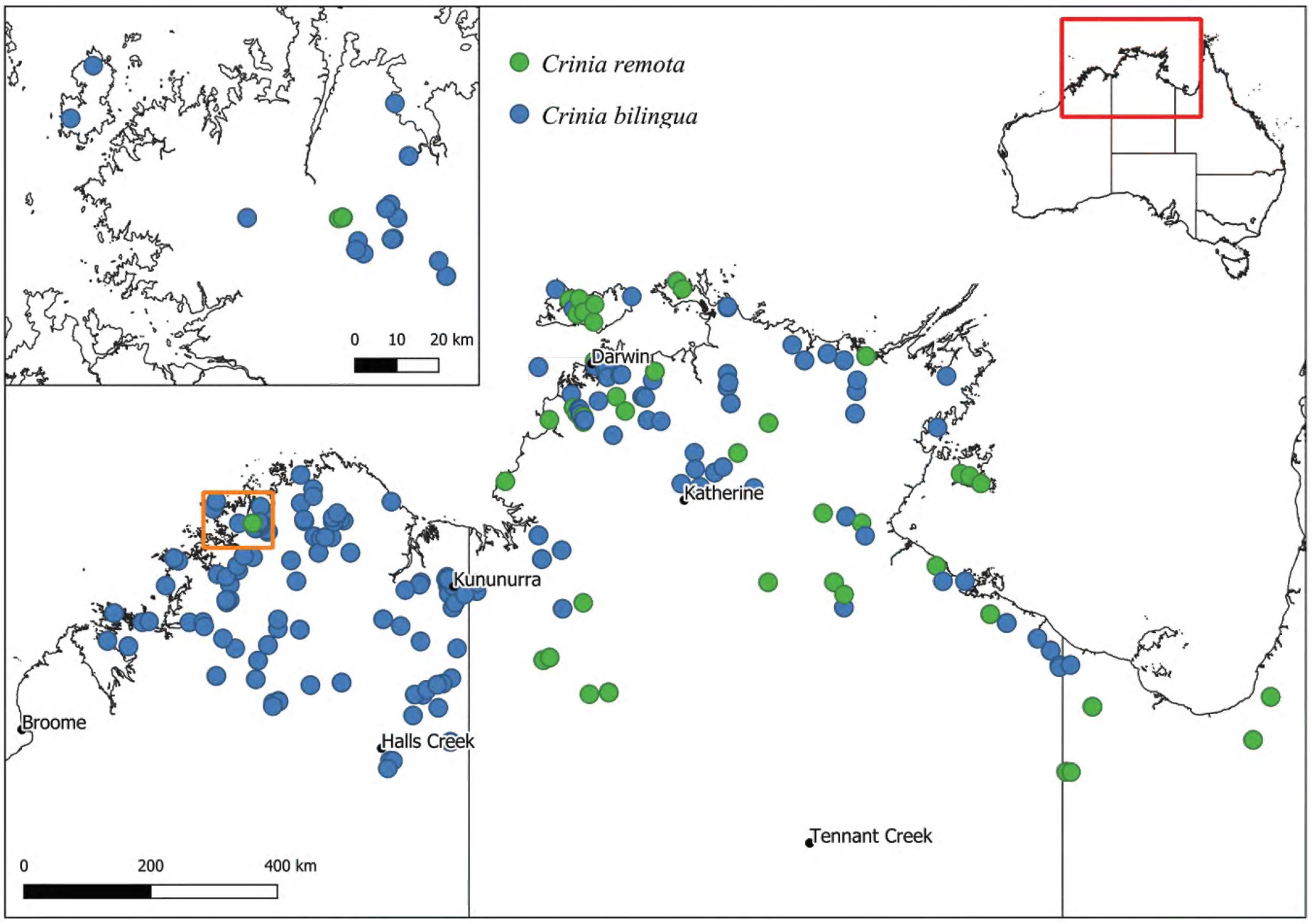

Figure 1. Map of the Australian Monsoonal Tropics, including the Kimberley region, Western Australia and Top End, Northern Territory (upper right-hand map shows the general location within Australia). Occurrences of *Crinia remota* and *C. bilingua* are based on specimen records from the WAM and Northern Territory Museum. Upper left-hand map shows zoomed-in area of the northern Kimberley region, including the Mitchell Plateau where *C. remota* was detected.

Among the distinctive ratchet-like two-part call of *C. bilingua*, a distinctive rattling sound was heard among them that was unlike the call of any other known Kimberley frog species. Following the sound, two specimens were located and then recorded prior to capture. Both specimens were vouchered and accessioned into the herpetological collection of the Western Australian Museum (WAM: WAM R171577 and WAM R171582; Fig. 2).

Following a more detailed analysis of the calls on return from the survey on Raven Pro v. 1.5, the call for both specimens was found to comprise of 12–15 pulses issued at a rate of approximately 35 pulses per minute. The call matched those of other *C. remota* calls available online (e.g. FrogID – frogid.net.au). Figure 3 presents a sonogram of both *C. bilingua* and *C. remota*, illustrating the distinctiveness of the calls.

During a genetic barcoding screen of Kimberley *C. bilingua* with the CO1 gene, one of the collected individuals (WAM R171582) came out highly distinctive compared to 25 other Kimberley *C. bilingua* (unpublished data; the other specimen, WAM R171577, was not tested). In addition, two other barcoded male specimens were identified genetically as *C. remota*

Figure 2. *Crinia remota* (WAM R171582) from Little Mertens Falls, Mitchell Plateau, Western Australia. Photo: P. Doughty.

from approximately 200 m east of where the calling *C. remota* males were encountered, but were collected in 2007 (WAM R167708, WAM R167709) when they were identified as *C. bilingua* at the time. Further genetic screens of *Crinia* from the Kimberley were carried out for the description of *C. fimbriata* Doughty, Anstis & Price, 2009, with genotyping of 13 additional *C. bilingua* from across the Kimberley but revealing no further *C. remota*.

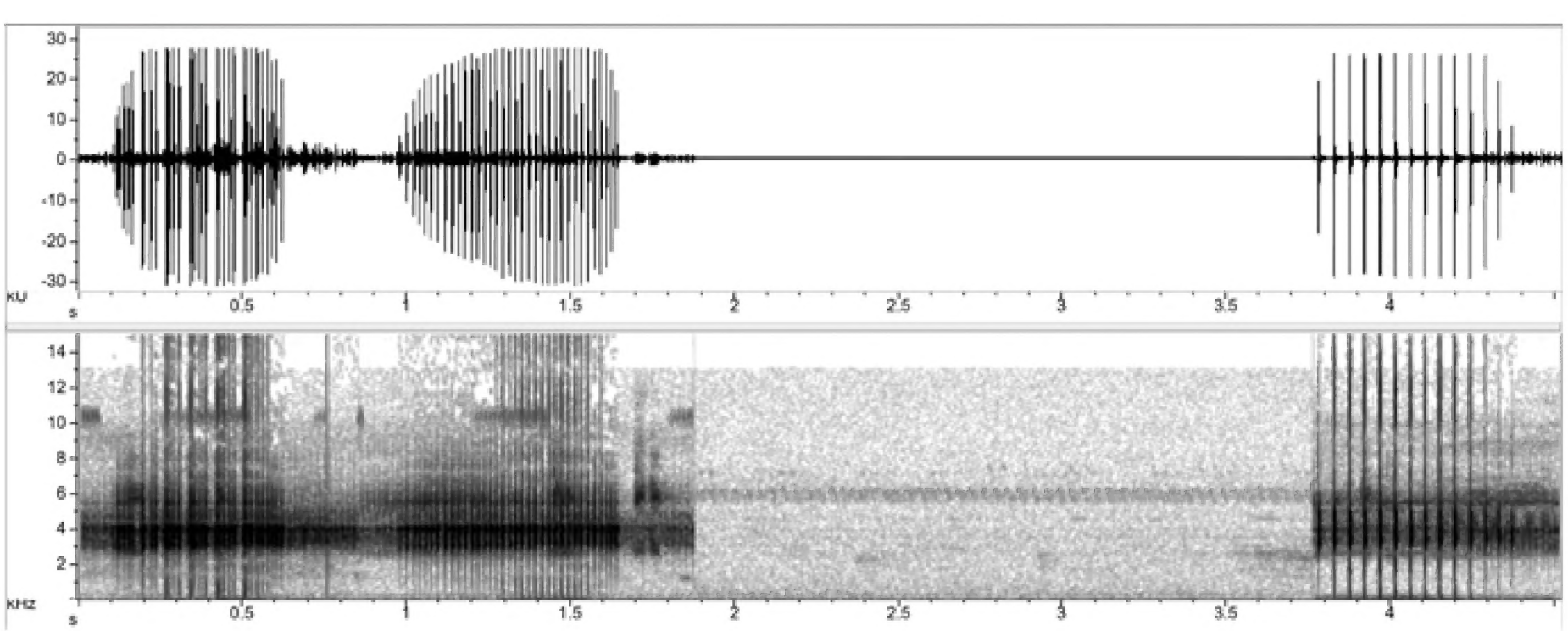

Figure 3. Sonogram and frequency analyses of the calls of *Crinia bilingua* (two calls to the left) and *C. remota* (right). Note the differences in pulse rate (upper figure) and dominant frequency (lower figure). Figure prepared by J.D. Roberts on Raven Pro v. 1.5.

The recorded or genotyped *C. remota* were very small in body size, with the four adult males measuring 15.0, 16.0, 16.0 and 17.5 mm from snout to urostyle, and masses from 0.3–0.4 g. In contrast, nearly 60 *C. bilingua* with lengths or masses recorded in the WAM database indicate maximum sizes of calling males at 24.0 mm (mean±SD: 20.18±1.51; N = 39) and mass at 0.8 g. For *C. bilingua* females maximum size was 28.5 mm (mean±SD: 21.28±3.33, N = 9) and 1.1 g.

A search through the existing preserved specimens at the WA Museum failed to convincingly provide other positive examples of *C. remota* among the numerous *C. bilingua* specimens; however, distinguishing the two species can be difficult owing to the similar range of body sizes of specimens (especially the occurrence of juveniles and subadults) and the ambiguity in descriptions of field guides such as the visible or hidden tympanum (Martin *et al*. 1980) or the degree of granularity of the skin on the venter (e.g. Clulow & Swan 2018) which were obscured by cuts in preservation.

Examination of historical records on the Atlas of Living Australia (ala.org.au; accessed 16 July 2021) showed several older records of *C. remota* from the Kimberley region at the Australian Museum (Sydney) and Museums Victoria (Melbourne). The Australian Museum specimen was over 21 mm, and accordingly reclassified as a *C. bilingua* (D. Trembath, pers. comm.). The Museums Victoria specimens have likely retained the older name of *C. remota* as they were collected before *C. bilingua* was described. Lastly, Cogger (2014) depicts a *C. remota* from "Carrington, WA" but this location is from Queensland (M. Anstis, pers. comm.).

Discussion

The occurrence of *C. remota* in the northern Kimberley some 400 km north-west of populations in the Northern Territory calls attention to similar biogeographic patterns with other frog species. The diminutive *Litoria microbelos* (Cogger) is widespread in the Top End, but in the Kimberley has only been known from the Mitchell Plateau since the 1970s and more recently detected at the Drysdale River National Park approximately 120 km to the east (Tyler & Doughty 2009). Both *C. remota* and *L. microbelos* have very small body sizes (<18 mm, the smallest frog species for each family in Western Australia), suggesting a relationship between small body size and regions with high rainfall. The north-west Kimberley also harbours the small-bodied endemics *Crinia fimbriata*, *Litoria axillaris* Doughty and *Uperoleia micra* Doughty & Roberts. *Litoria tornieri* Neiden is another small to medium-sized species that appears to be in low numbers from the "Ord region" (sensu Catullo *et al*. 2014) but that is common in the northern Kimberley and Top End, suggesting it fares less well in this drier region.

The occurrence of disjunct populations in the Kimberley of *C. remota* and other frog species from Top End populations suggests that recent climate change has resulted in range contraction. The existence of many endemic frogs and reptiles that occur only in the northern Kimberley also supports a role of past climate change and contraction of ranges as a driver of speciation in the Kimberley.

Several biogeographical reviews suggest a drying of the lowland areas in the Australian Monsoon Tropics from about 25,000–15,000 years ago (Bowman *et al*. 2010; Pepper & Keogh 2014). If so, then this would suggest the Kimberley and Top End populations are only relatively recently diverged from each other.

The discovery of *C. remota* in the Kimberley on a recent wet season survey also underscores how much more field work is required to properly document the fauna from this highly diverse region (see also Doughty 2011; Doughty *et al*. 2012). In addition, refinement of the characters used to separate both of these northern *Crinia* species with similar appearance include analysis of frog calls, genetic analyses and a review of morphological characters that could assist in identifying species such as *C. remota* from *C. bilingua*. As Tyler and Davies (1986) remarked, however, "The subtle differences that distinguish *R.* [*Ranidella* = *Crinia*] *remota* from *R. bilingua* indicate that these species are likely to be separated by collectors only with great difficulty" (p. 56).

Acknowledgements

I thank Butch Maher and Matthew Barrett for accompanying me on the field survey, Ian Brennan, Ryan Ellis and Mark Cowan for helpful comments on the manuscript, Ryan Ellis & Biologic Environmental Survey for the map figure, Dale Roberts for the sonogram figure, Dane Trembath and Katie Date-Smith for checking specimens, Scott Eipper and an anonymous reviewer for constructive suggestions and the Barcode of Life Data System (Ratnasingham & Hebert 2007) for genetic sequencing.

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Growth anomalies affecting Cocos (Keeling) Island's coral reefs: a case study of coral disease in Western Australia

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Abstract

Growth anomalies are a tumour-like coral disease, affecting key reef-building corals across global coral reefs. This disease is observed as pale protruding masses, affecting polyp development and causing abnormal skeletal growth patterns. It is typically associated with thermal stress events or proximity to large anthropogenic centres. Here, I review the work undertaken to characterise a unique occurrence of this disease that was reported to be affecting *Isopora palifera* at the Cocos Keeling Islands in 2019. I attempted to determine the distribution of affected *I. palifera* across the remote atoll and characterise the effects of the disease on the host at both an ecological and bacterial level. Growth anomalies were reported to be affecting *I. palifera* at 75% of sites surveyed and compromised the biological and reproductive functioning of the host, having important implications for the future reproductive potential of the population. There were no differences in bacterial communities hosted in diseased and healthy corals and, importantly, no associations with potential point sources of aquatic pollution in the atoll. The occurrence of growth anomalies is unique at Cocos, given that there were no obvious triggers that have been established for other outbreaks of growth anomalies, and challenges the current perception of the instigation of this disease globally. Finally, I highlight the lack of understanding of the extent and distribution of coral diseases across the whole of Western Australia.

Introduction

Coral reefs are complex and dynamic systems, facilitating a productive marine environment. The loss of such ecosystems as a result of climate change and localised anthropogenic pressure is estimated to cost $US500 billion by 2100 (Hoegh-Guldberg *et al*. 2015). Since 1980, the average global temperature has increased by 1°C, with marine heatwaves sweeping the Indo-Pacific and Caribbean reefs in 2016/17 and 2019/20 (Burt *et al*. 2019; Eakin *et al*. 2019; Gilmour *et al*. 2019). The effects of climate change can result in changes to community composition (Hughes *et al*.

2018) and loss of marine biodiversity (Cinner 2014), and recent estimates have demonstrated all corals will be threatened by 2050 (Ainsworth *et al*. 2020). The direct and cumulative effects of climate change and anthropogenic pressure can lead to bleaching events (Hughes *et al*. 2018), tropicalisation of temperate reefs (Vergés *et al*. 2019), mass mortality events (Hughes *et al*. 2019) and increased prevalence of coral diseases (Weil & Rogers 2011; Bourne *et al*. 2015; Montano *et al*. 2016; Mohamed & Sweet 2018).

Over 40 coral diseases have been reported across the Indo-Pacific and Caribbean coral reefs (Woodley *et al*. 2015), with their prevalence an important parameter in monitoring reef health. An outbreak of coral disease can lead to the decimation of populations, e.g. the loss of the endangered elkhorn coral in the Caribbean (Patterson *et al*. 2002). Coral diseases are predominantly a tropical phenomenon, as outbreaks can be triggered or exacerbated by thermal stress events (Bruno *et al*. 2007). As warmer water extends further south as a result of climate change, coral diseases pose a significant threat to temperate corals experiencing thermal anomalies (Vergés *et al*. 2019). Growth anomalies are a skeletal disease commonly associated with thermal stress events, or anthropogenic pressure (Aeby *et al*. 2011). The disease appears as a pale tumour-like mass affecting polyp development and skeletal growth patterns (Domart-Coulon *et al*. 2006; Work *et al*. 2008). Despite its prevalence, the causal agent of growth anomalies and the dynamics of its transmission among hosts is yet to be established.

In 2018, an outbreak of growth anomalies (GAs) was reported from the Cocos (Keeling) Islands (CKI), affecting the reef-building scleractinian coral species *Isopora palifera*, a club-like branching coral related to the genus *Acropora* (Richards & Newman 2019). The coral reefs of CKI have escaped significant thermal stress events in recent history (Gilmour *et al*. 2019), and are subject to low anthropogenic pressure due to the small human population and remote location of the atoll. The potential triggers of the unique occurrence of growth anomalies were not immediately obvious.

This research project had two aims. First, I aimed to investigate the distribution and abundance of *I. palifera*, quantify the proportion of colonies affected with growth anomalies and establish the effects of the disease on this species. Second, I set out to describe the bacterial communities hosted within the healthy and diseased corals, to identify any shared indicator taxa. I also compared coral-hosted bacterial communities to communities identified within the water column, including from two potential sources of aquatic pollution. Here, I provide an overview of the research on this problem from Preston (2021), Preston & Richards (2021) and other manuscripts currently in preparation. Presentation of the methods and results have been simplified; more details are available in the original papers.

Methods

In 2019, a field trip was undertaken to CKI to characterise the occurrence of GAs using ecological and molecular methods. Field surveys and specimen collection were undertaken from 17–24 May, where 11 sites were chosen based on where GAs were observed in a

previous study (Alexander *et al*. 2019; Richards & Newman 2019) factoring in prevailing weather conditions and time constraints (Fig. 1). Ecological surveys consisted of three *I. palifera* specific belt transects (10 x 25 m) per site, and three benthic communities and coral cover surveys (25 m point intersect transects) per site. Specimens were collected at four sites, from both affected and healthy control colonies. Growth anomalies were identified as paletumorous masses protruding from the host colony (Fig. 2). Sites ranged between 11–14 m in water depth, with the exception of Blue Hole 5 (1–3 m depth) in the southern lagoon. Nine sites were selected where GA-affected *I. palifera* colonies were at an appropriate size to allow for replicate branches to be sampled from each colony. Size measurements (height, average branch length from three branches) were collected via flexible tape measure from each sampled colony to provide descriptive context,

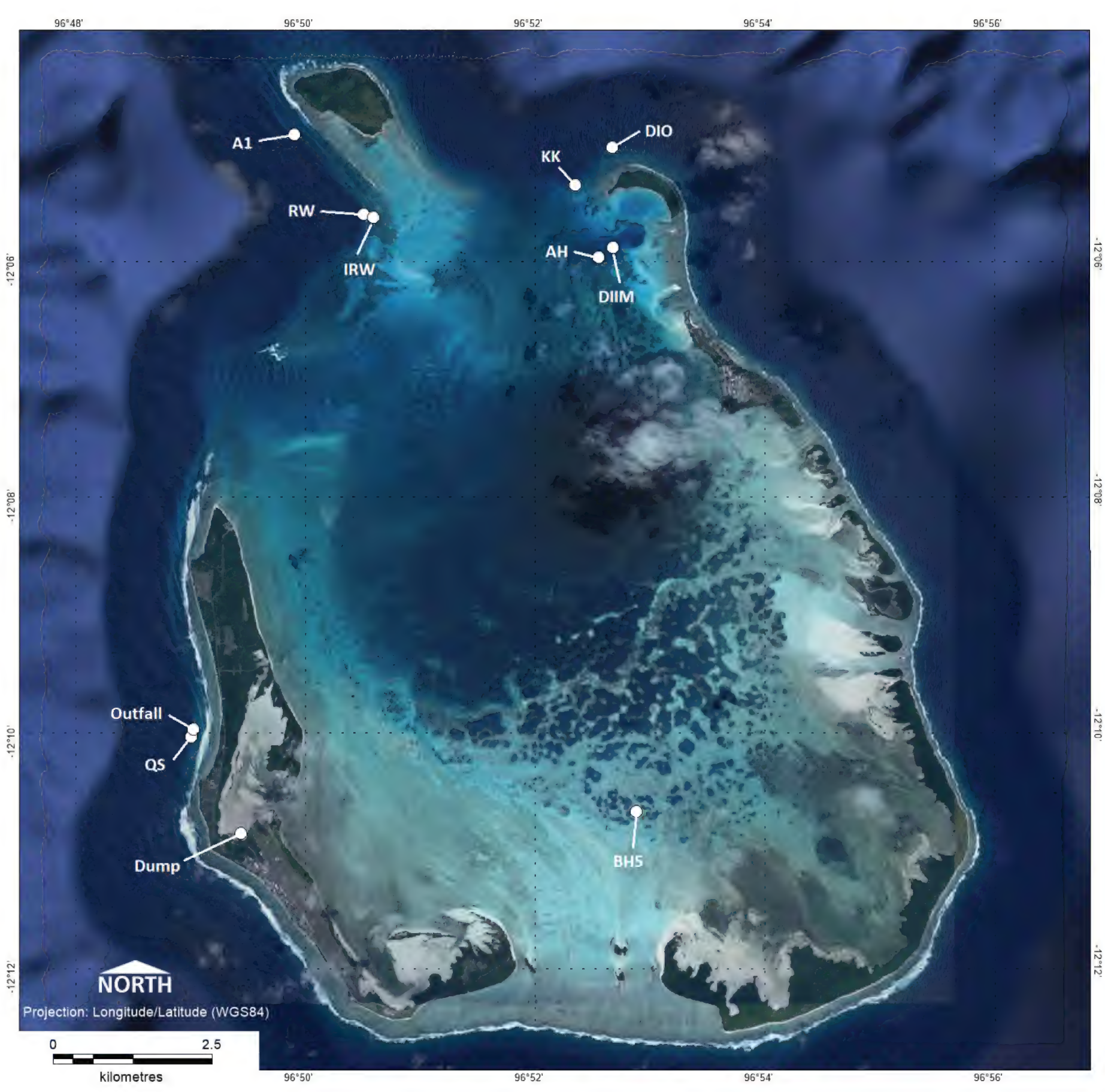

Figure 1. Map of sites surveyed at the Cocos (Keeling) Islands. Depths ranged between 3–14 m (Preston & Richards 2021).

Figure 2. Photographs of *Isopora palifera* in situ: a) healthy colony, b) GA-affected colony, c) closeup of GA lesion, d) observed fish scrape upon lesion. Photos: Zoe Richards (Preston & Richards 2021).

and the proportion of colony covered in lesions was scored as in Preston and Richards (2021). Samples were stored separately in seawater to prevent cross-contamination until processed in the field. Here, each branch was sub-sectioned into GA-affected, adjacent asymptomatic (e.g. apparently 'healthy' from same branch as GA sample obtained) and healthy control. These sub-sections were to be subjected to further analyses to be conducted later in Perth.

The molecular approach consisted of describing the bacterial associations of GA-affected corals in comparison to healthy control samples. These were compared to bacteria found within the water column near diseased colonies as well as samples taken from possible point sources of aquatic pollution (e.g. the West Island sewerage outfall and dump). The water samples were filtered in the field laboratory and the filter paper from the sample was kept frozen until processing at a quarantine facility in the Trace and Environmental Laboratory, Curtin University (Preston 2021).

Back in Perth, bleached and air dried skeletons underwent X-ray fluorescent analysis and scanning electron microscopy to map the topography of the skeleton, and note changes to trace element accumulation within the skeletal matrix. Histological analyses of tissues were used to examine change to the biological and reproductive functioning of the host. The DNA sequences of bacteria were extracted from whole coral samples and examined for any differences in community composition among the health status of the samples (GA-affected, adjacent asymptomatic, and control healthy), as well as compared to the bacterial communities extracted from the water column. Data analyses were conducted on all datasets, predominately examining differences between health status (diseased, asymptomatic, control) and among sites (Preston 2021; Preston & Richards 2021).

Results and Discussion

The ecological surveys reported 1322 *I. palifera* colonies, the sixth-most abundant species of hard coral within the survey area (Preston & Richards 2021). One-third of these were affected by GAs, with the disease present at 75% of sites surveyed (Fig. 3a). The only sites that did not record any GAs were Quarantine Station and Aquarium Wall 1 on the western edge of the atoll. The disease also exceeded two published thresholds for quantifying an outbreak of disease: 60 cases per 1500m^2 (Maynard *et al*. 2011); affecting 5% of colonies (Willis *et al*. 2004) (Fig. 3b).

This disease appears to affect the growth and development of the host with the findings consistent with reports of GAs on other species (Domart-Coulon *et al*. 2006; Williams *et al*. 2011; Kelly *et al*. 2016). Scanning electron microscopy indicated significant alteration to skeletal growth processes, resulting in a loss of skeletal organisation and abnormal development (Fig. 4). There appeared to be a significant difference in the trace element accumulation between GA-affected skeletons and their healthy counterparts. This abnormal growth pattern appeared to be to the detriment of biological and reproductive function, as histological sections confirmed a reduction in all components measured. Impacts to host function

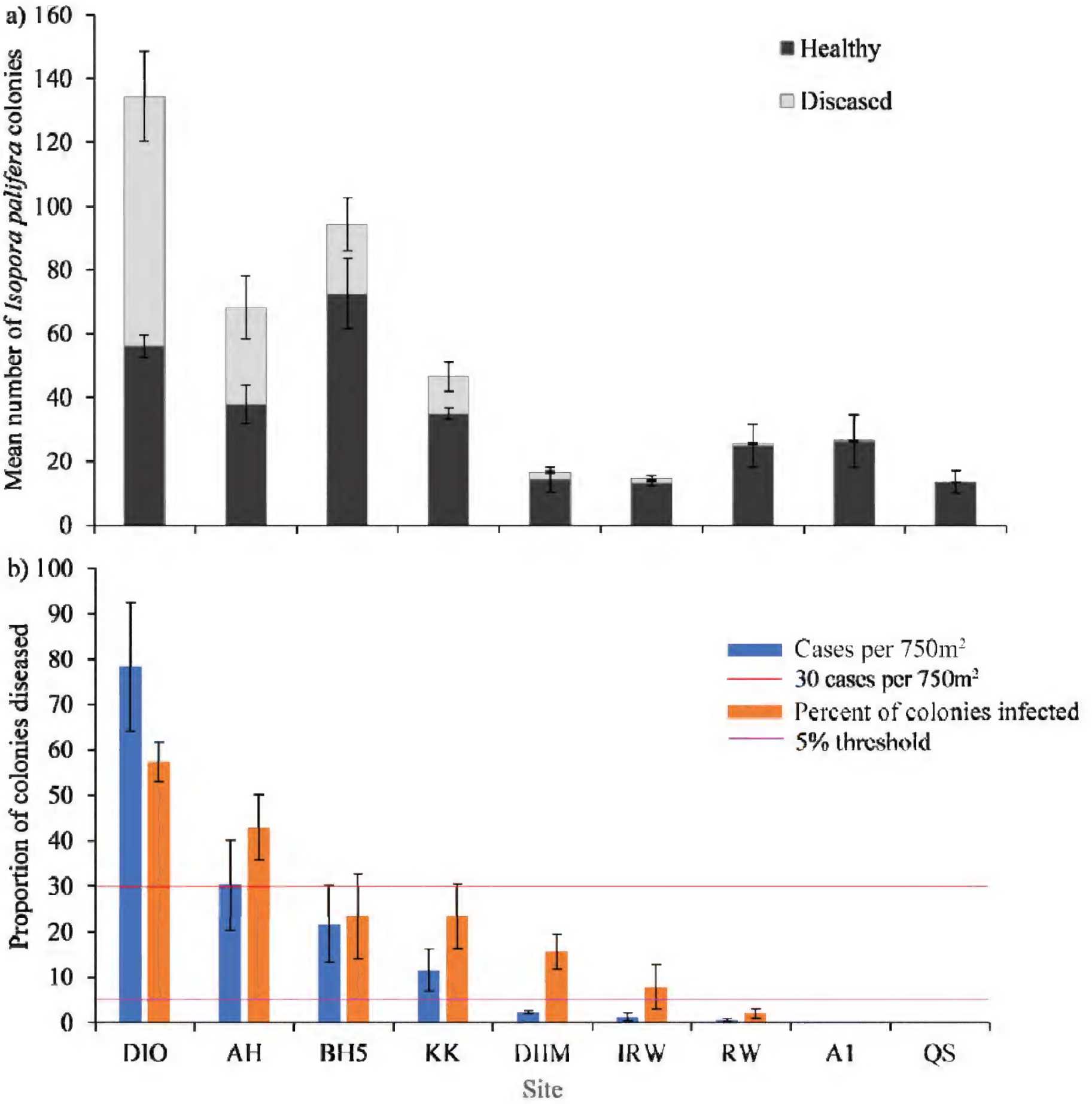

Figure 3. a) Number of healthy and diseased *Isopora palifera* colonies per site (mean±SE), b) proportion of affected colonies only, compared to published threshold levels (Preston & Richards 2021).

appeared to be confined to lesions with adjacent asymptomatic tissues displaying similar proportions of biological and functional components to control healthy tissues (Preston & Richards 2021). Given that on average, GAs covered 40% of the surface area of the host and affected one-third of the local population, there may be significant consequences for the future reproductive potential of the population.

There were broad similarities found in the bacterial associations of all corals sampled, instead associations displayed significant variations between site, a result of the spatial-temporal variation characteristic of the coral microbiome. There were no indicator taxa found between

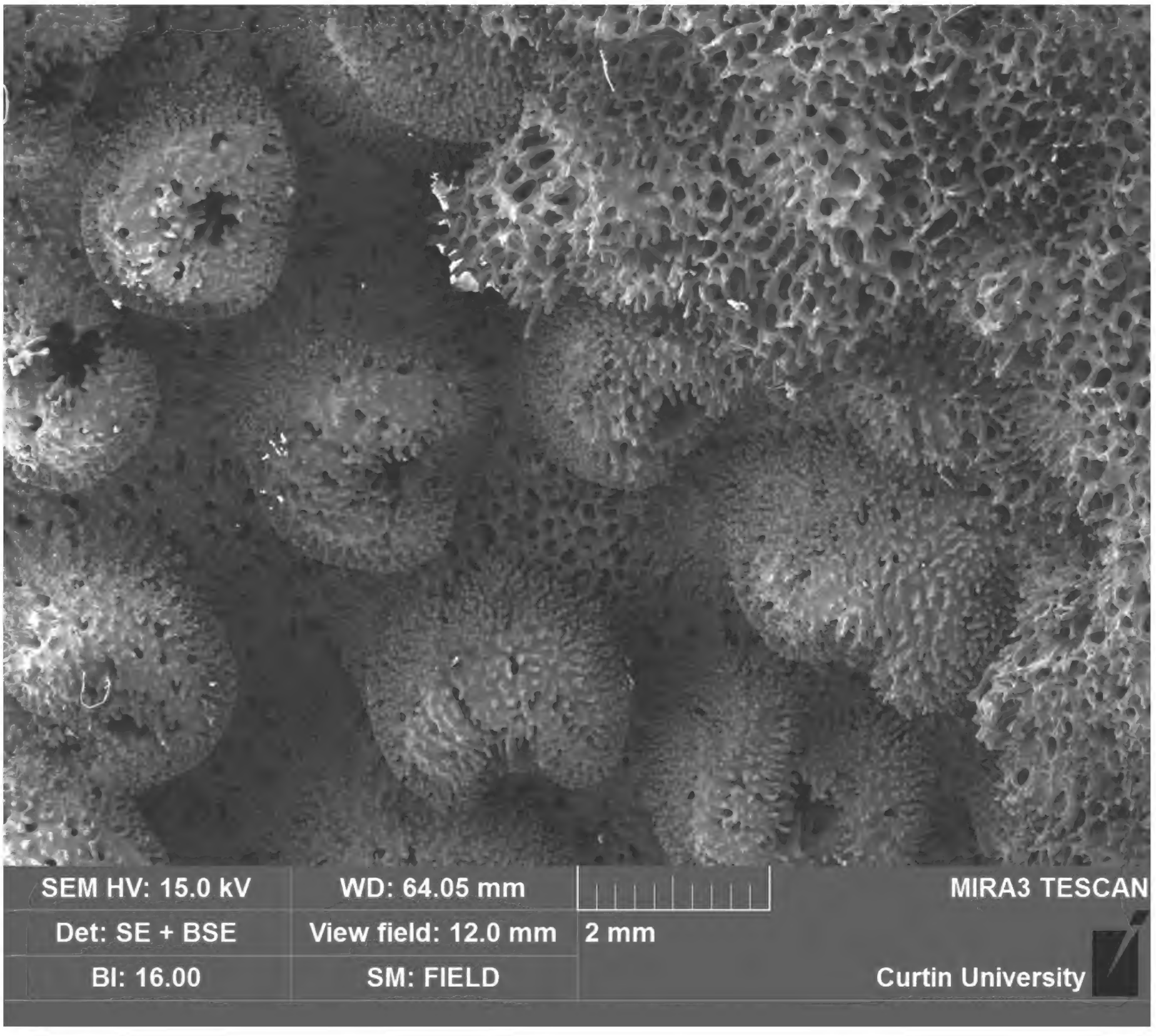

Figure 4. Skeletal topography of a transition zone between healthy (bottom left zone) and diseased (top right zone) growth anomaly. Note the lack of structure and organisation in tumour-like growth of the GA-affected corals. Photo: Sophie Preston.

water samples and coral samples, in particular no associations with potential point sources of aquatic pollution. Collectively, these results indicate that the causal agent is unlikely to be transmitted through the water column or that it is bacterial. Further details into the community structure and composition of both the coral and the surrounding water column can be found in Preston (2021).

This is the first study of growth anomalies to account for both environmental and health status factors with a large sample size. It contributes to the global knowledge of coral diseases by demonstrating patterns that differ from the current understanding that GAs are caused by abnormal thermal stress events or bacteria. Future research should continue to investigate the transmission of this disease across the CKI reefs which could reveal the causal mechanism. In particular, corallivorous fish have been associated with both the onset of disease through the transport of pathogens in faeces or creating physical

lesions (Rice *et al*. 2019), and with the clean-up of disease (Chong-Seng *et al*. 2011). Given that there were no shared bacterial taxa between diseased states, future investigations should also consider the role of other microbial agents such as fungi or marine viruses as implicated in other coral diseases (Soffer *et al*. 2014; Soler-Hurtado *et al*. 2016).

Future directions: coral diseases in Western Australia

Western Australia hosts several important coral reef habitats that require monitoring to assess the cumulative effects of climate change, from the intertidal zones of the Kimberley to the mesophotic corals of offshore Ashmore and Scott Reef (Gilmour *et al*. 2019). The Australian Institute of Marine Science's (AIMS) Long Term Monitoring Program has been monitoring Scott Reef since 1994 (Gilmour *et al*. 2013). Within the state, the Department of Biodiversity, Conservation and Attractions (DBCA), has established long term monitoring programs at key sites, such as Ningaloo Reef, the Montebello Islands and Barrow Island (Bancroft 2011; Cary *et al*. 2000; DBCA 2017). Whilst the DBCA marine science program has sought to establish a preliminary baseline (Simpson & Waples 2010), effort is predominately focused on monitoring the prevalent and pressing issue of coral bleaching as well as other indicators of marine ecosystems and health.

While coral bleaching is at the forefront of reef health surveys, little is known regarding the extent of coral diseases in Western Australia. Surveys are generally conducted in association with industry-associated activities such as dredging and infrastructure construction (Pollock *et al*. 2016; Stoddart *et al*. 2019). The World Heritage-listed Ningaloo Marine Park has been surveyed for coral disease, with a focus however, on Coral Bay (Onton *et al*. 2011). The Abrolhos Islands and offshore Christmas and Cocos (Keeling) Islands have produced a limited number of reports of white syndromes each (Hobbs & Frisch 2010) and a number of occurrences have been recorded in the Pilbara region (Page & Stoddart 2010). Coral disease is prevalent along the Western Australian coastline, yet we do not fully understand the extent or trends of this threat. A warming ocean will increase the number of coral disease outbreaks (Maynard *et al*. 2011). A comprehensive baseline is required to understand the extent of disease, and how this changes under the influence of environmental stressors over time to inform effective mitigation and management strategies.

Western Australia hosts several important coral reef habitats to monitor the cumulative impacts of climate change. The Abrolhos Islands in particular are in a key location for monitoring the changes in coral reef health as a result of tropicalisation (Verges *et al*. 2014, 2019), as they are ideally positioned latitudinally between tropical and temperate zones, and have already begun to experience coral bleaching events (Abdo *et al*. 2012). Rottnest Island, a temperate reef, is also beginning to experience tropicalisation events such as changes to fish assemblages and has also been subject to coral bleaching (Thomson *et al*. 2011; Hyndes *et al*. 2016; Richards *et al*. 2016). It is important to establish a baseline reef health for these key

habitats to best protect them in the future and to identify any early changes and implement mitigation and management methods where possible.

Acknowledgements

This project was funded by the Seventy Memorial Prize from the WA Naturalist Society, a William McLeay Microbiology grant from the Linnean Society of New South Wales and by an ARC Linkage project (LP160101508) awarded to co-investigator and supervisor Zoe Richards. Coral samples were collected under Fisheries Exemption No. 3080. I thank everyone who contributed across all projects associated with this review, including Megs and Taj Powell and Dieter Gerhard of Cocos Dive, my co-authors, colleagues at the Trace and Environmental DNA Laboratory, especially Matt Heydenrych and Katrina West and the Coral CORE group.

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Records of Osprey in Perth, Western Australia

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Abstract

The Osprey (*Pandion haliaetus cristatus*) was uncommon in Perth until the mid-1980s. Anecdotal information indicates nesting and breeding started about 20 years ago. A monitoring program initiated in 2016 has followed nesting sites along the Swan and Canning Rivers and the Perth coast for a five-year period. Nesting sites are close to the ocean or river, and often close to a bridge. Nests are usually high in trees or man-made structures with available perches. There is a stable Osprey population of between five to seven breeding pairs, with the number of fledged young being 1.4 per successful territory per year.

Introduction

The Osprey (*Pandion haliaetus cristatus*) is a bird of prey with a global distribution. In Australia they are non-migratory, inhabiting warmer coastal waters and estuaries (Poole 2019). They are absent from Tasmania, Victoria and parts of the southern coast of Western Australia (WA) (Dennis & Clancy 2014; Marchant & Higgins 1993). In WA, high population densities occur at the Houtman Abrolhos Islands (Surman 2019) and around Barrow Island and the adjacent Montebello Islands (Sedgewick 1978; Johnstone *et al.* 2013). They feed mainly on surface fish and were known as a Fish Hawk by colonists of the Swan River (Gould 1848).

Males and females can be distinguished by differences in size and plumage. Females are longer and heavier than males, being about 20–30% greater in mass and about 10–15% longer in the wing (Poole 2019). Adult females have a broad band of streaks across the upper breast. Most adult males have a clean white upper breast, but some males have a pale, thin chain of streaks similar to, but paler than that of the females.

Osprey nests are large and conspicuous, and they are loyal to their nesting sites. For example, in WA successive generations of Osprey have nested at Cape Mentelle at the mouth of the Margaret River, for more than 130 years. A.J. Campbell visited this site on 5 November 1889 and found an Osprey nest on a small, isolated rock with young fledgelings (Campbell 1901). H.M. Whittell visited the islet on 5 November 1932 and found Osprey had built another nest on the mainland, within a hundred yards of the original (Whittell 1932). They have continued to breed at this location: on 25 November 2020, there was a nest with one chick on a limestone cliff ledge close to past sites (H. Durlik, pers. comm.), and

all three known nesting sites at Cape Mentelle are close to each other.

Nests can become quite large as nesting material accumulates over the years. The nest at Cape Mentelle was about 4 feet high and about 13 feet in circumference (Campbell 1901) and a nest at Broke Inlet was about 5 feet high (Whittell 1932). Osprey will also adopt human-made structures as nesting sites and use artificial nesting platforms, telecommunication towers and one was even found to nest on a lighthouse gallery (Serventy & Whittell 1976; Saunders & de Rebeira 1993).

The female Osprey does most of the nest building and incubation. Eggs are laid one or two days apart, and incubation often starts with the first egg which results in asynchronous hatching over 3–5 days (Marchant & Higgins 1993; Poole 2019). In Australia juveniles can disperse over considerable distances (Holsworth 1965).

Historical information of Osprey distribution around Perth

Early naturalists (Gilbert in 1839 and 1842; Campbell in 1889, Le Souef in 1902) reported Osprey breeding on Perth's off-shore islands, including Penguin Island (Gould 1848; Campbell 1901, Holsworth 1965), but do not mention Osprey breeding along the Swan or Canning Rivers. Serventy & Whittell (1976) mention that Osprey rarely venture inland but are occasionally seen on the Swan River estuary, as far as the Causeway. Storr & Johnstone (1988) note that Osprey occasionally occur as far upstream as Guildford but were not aware of any breeding records in Perth. Whilst Maddeford, a naturalist who grew up around the Swan River and monitored birds from the late 1960s onwards, remembers that Osprey were very uncommon on the river until about the mid-1980s (W. Maddeford, pers. comm.). Johnstone (WA Museum) found no historical Osprey breeding records for the Swan River until the mid-1980s, and most are very recent, in the early 2000s (R. Johnstone, pers. comm.).

It appears Osprey occasionally ventured up the Swan River, with increasing sightings from the mid-1980s, and breeding records increasing more recently. There are two aims of this paper: firstly, to collate anecdotal records of nestbuilding and breeding success from published and unpublished sources; secondly, to present the results of a monitoring program on the population density, number of breeding pairs, productivity and location of nesting sites around Perth between 2016–2020 (Fig. 1).

Methods

Anecdotal records

Information was collected on past and present Osprey nesting sites by talking to local residents and from published observations.

Monitoring program

The anecdotal records were used to select locations for a more detailed study between 2016 and 2020. Additional locations were added when new nests were noted, resulting in a variable number of nesting sites being monitored each year (Fig. 1).

Volunteers assisted in the collection of data and are recognised in the Acknowledgements. Monitoring commenced in May when Osprey returned to their nesting sites and

Figure 1. Map of nest sites around Perth 2016–2020. Green markers: successful and active sites; red markers: occupied sites; yellow markers: vacant platforms.

were observed bringing back nesting material; it ceased in January when the last young had fledged. Surveys were conducted monthly, often more frequently during the breeding season.

Observations were recorded during the visits and behaviour patterns noted. Raptor survey and research terminology was adapted for this study (Poole 1989; Dennis 2007):

- Occupied territory: where a pair of adult birds appear together in the breeding season in the vicinity of the nest(s) and territorial defence is observed.
- Active nest or territory: a site where eggs are laid (may be determined from prolonged incubation behaviour only) or young are recorded. Prolonged in this instance was taken as 2–3 weeks.
- Successful nest or territory: a nesting site from which young fledge.
- Failed nest or territory: where eggs fail to hatch, or where eggs or young are lost, e.g. due to predation or severe weather.

Prey

Field observations and photographs were used in the identification of the fish and other species.

Threats

Opportunistic observations identified a number of threats to Osprey.

Results

Anecdotal records

Anecdotal records are given in Table 1 and ordered by suburb. The location of 34 nest sites were identified during the study. The nest sites were in the top of Norfolk Island pines (24%) (Fig. 2), on telecommunication towers (21%), on artificial nesting platforms

Figure 2. Osprey on nest in Norfolk Island pine at Crawley, Old Swan Brewery site, July 2021. Photo: Marcus Singor.

Table 1. Anecdotal records of Osprey nests and breeding success in the Perth area. Records are from Bailey 1993; Muir 2006; Observations Committee 1995; O'Connor 2003, 2005; Singor 2009; Stranger 2017; Vervest 1990, and J. Bennett (pers. comm.), R. Dawson (pers. comm.), P. Ewing (pers. comm.), D. Free (pers. comm.), C. Greenwell (pers. comm.), M. O'Brien (pers. comm.) and G. Tate (pers. comm.).

Location	Date	Nesting site	Comments
Ascot, Garratt Road Bridge	Before 2006	Radio tower	Breeding successful in some years.
Ascot, Grove Farm	1993	Aerial-like structure	Not known.
Ascot, Ron Courtney Island	Before 2016	Large eucalypt tree	Breeding successful in 2016.
Attadale	Since 1990	Radio tower, platform installed	Breeding unsuccessful.
Claremont, Bindaring Parade	Early 1980s	Tuart tree	Breeding successful 2002, 2003, 005, 2006, 2008, 2009, 2011; nest destroyed 2013. Known as Devil's Elbow.
Claremont, Jetty	Before 2010	Norfolk Island pine	Breeding successful 2010.
Como	2005	Norfolk Island pine	Osprey nesting in October 2005; unoccupied in 2009.
Crawley, Old Swan Brewery	Since 2008	Norfolk Island pine	Breeding successful in 2008 and 2009.
Crawley, Pelican Point	Around 2004	Dead tree	Breeding successful around 2004, one young raised.
Crawley, Pelican Point foreshore	Since 2015	Platform installed, upgraded 2021	Never occupied.
Coogee	Since 2012	Platform	Installed in 2012. Platform never occupied.

Hillarys, Beach Park	Since 2015	Telecommunications tower	Young raised each year since November 2015.
Joondalup, Lake Joondalup	Since 2016	Paperbark tree	Breeding unsuccessful, nest blown down in March 2020.
Mindarie, Marina	Before 2016	Egyptian Rowboat sculpture	Young raised for more than 6 years. Nest removed in 2016.
Mindarie, North Foreshore Reserve	Since 1999	Platform installed by Mindarie Keys Coastcare Association	Generally not occupied. Osprey present June, July 2021.
Mindarie, Tuart Grove	Since 1999	Platform installed by Mindarie Keys Coastcare Association	Never occupied.
Mosman Park, Bay View Park	Since 2012	Tuart tree	Nest destroyed 2015.
Mosman Park, Green Place Reserve	Since 2009	Norfolk Island pine	Breeding unsuccessful.
Mount Pleasant	Before 2016	Norfolk Island pine	Breeding successful in 2015/2016, 2 young raised.
North Fremantle	Before 2016	Boatlift	
Peppermint Grove, The Esplanade	Since 2014	Norfolk Island pine	Established after Claremont, Bindaring Parade site ceased.
Quinns Rocks	Early 2000s	Telecommunications tower	Nested in tower, later removed.
Salter Point	Before 1996	Dead Tuart, platform installed 1998	Breeding successful in 1996, 2005 onwards.
Waterford, Bodkin Park	Before 2016	Dead paperbark tree	Breeding successful in 2015/2016, 3 young raised.
Waterford	Before 2016	Not known	Site not successful.

Table 2. Monitored Osprey nesting sites in the Perth area, 2016–2020 (Singor 2017, 2018, 2019a, 2020). Definitions (see Methods) are as follows: Occupied: occupied territory; Active: active nest or territory; Successful: successful nest or territory, number of fledged juveniles in parenthesis; Vacant: not in use.

Location	2016	2017	2018	2019	2020	Nest location
Ascot, Garratt Road Bridge	Occupied	Occupied	Occupied	Vacant	Successful (2)	Radio Mast
Ascot, Ron Courtney Island	Successful (1)	Occupied	Vacant	Active	Vacant	Eucalypt tree
Attadale	Occupied	Occupied	Vacant	Active	Active	Artificial nesting platform
Bentley, Curtin University			Successful (2)	Successful (2)	Successful (2)	Telecommunication tower
Bicton, Point Walter	Active	Active	Occupied	Vacant	Vacant	Norfolk Island pine
Bicton, Point Walter sandbar					Occupied	Low scrub
Coogee				Vacant	Vacant	Artificial nesting platform
Cottesloe		Occupied	Occupied	Occupied	Occupied	Norfolk Island pine
Crawley, Old Swan Brewery	Occupied	Successful (2)	Occupied	Successful (2)	Vacant	Norfolk Island pine

Crawley, Pelican Point		Vacant	Vacant	Vacant	Vacant	Artificial nesting platform
Hillarys, Beach Park	Successful (1)	Successful (1)	Successful (1)	Successful (1)	Successful (2)	Telecommunication tower
Joondalup, Lake Joondalup		Occupied				Paperbark tree
Mosman Park, Green Place Reserve	Occupied	Occupied	Occupied	Occupied	Occupied	Norfolk Island pine
Mount Pleasant, The Esplanade	Successful (1)	Successful (1)	Successful (2)	Occupied	Occupied	Norfolk Island pine
Munster, Austal site	Successful (1)	Successful (1)				On old tug boat
Peppermint Grove, The Esplanade		Occupied	Vacant	Successful (1)	Occupied	Norfolk Island pine
Peron, Gull Rock		Successful (1)	Occupied	Active	Successful (2)	Off shore limestone islet
Salter Point	Successful (2)	Successful (1)	Occupied	Successful (1)	Successful (1)	Artificial nesting platform
Shoalwater Bay,					Occupied	Limestone rock
Whale Rock South Perth					Occupied	Telecommunications tower
Victoria Park				Occupied	Occupied	Telecommunication tower
Waterford, Bodkin Park	Successful (1)	Occupied				Paperbark tree
Number of fledged juveniles	7	7	5	7	9	

(18%), in other tree species (17%) and at miscellaneous sites (20%). Miscellaneous sites included a boatlift, large metal sculpture, decommissioned tugboat and limestone islets.

Monitoring program

All monitored Osprey nesting sites were along the Swan and Canning Rivers, on the Swan Coastal Plain, and on coastal sites within or adjacent to a marine park (Fig. 1, Table 2). Over the 5 year period a total of 62 nests classed as either occupied, active or successful were monitored; 25 breeding pairs successfully fledged young.

New nests were built at Cottesloe (2017), Bicton (2020), Shoalwater Bay (2020), South Perth (2020) and Victoria Park (2019). At other sites nests fell into disrepair and nesting platforms at Coogee and Crawley (Pelican Point) remained empty.

Around Perth, peak nest-building activity took place between May and August when Osprey brought sticks and large clumps of seaweed to the nest. Seaweed was also brought in at the latter stages of nest building to line the cup of the nest, and nesting material was still being brought to the nest when young were present, and there is a short period of increased nest building or restoration activity, that takes place after the breeding season in late January to early February. Over the winter months, grass and weeds grew vigorously in some nests, with lush greenery completely covering the centre nest cup with growth up to 30 cm high. However, this vegetation did not stop Osprey from using the nest and young were raised surrounded by grass (M. O'Brien, pers. comm.).

There were 25 successful nests, with one to two juveniles raised per nest (Table 2), although a nest with three juveniles was observed in 2015 at Bodkin Park, Waterford, (Table 1). The number of fledged young per successful nest during the monitoring program is 1.4.

At Attadale a polyandrous relationship was observed during the 2020 season. This nest site was claimed by three Osprey, two males and a female. The three adults seemed in an apparent polyandrous relationship where both males were observed mating with the female. One male was opportunistic visiting the female when the other male was away fishing. The males were often seen sparring, although at other times they were sitting close together. The polyandrous arrangement persisted from June through to October. This nesting site was abandoned towards the end of October 2020.

Prey

Fish taken by Osprey from the Swan River estuary during the monitoring program include Black Bream (*Acanthopagrus butcheri*), Sea Mullet (*Mugil cephalus*), Yellowtail Trumpeter (*Amniataba caudavittata*), Yellowtail (or Bar-tailed) Flathead (*Platycephalus westraliae*) and Western Striped Grunter or Trumpeter (*Helotes octolineatus*). Coastal fish identified as prey were Smalltooth Flounder (*Pseudorhombus jenynsii*), Yellow-eyed Mullett (*Aldrichetta forsteri*) and Silver Trevally (*Pseudocaranx dentex*).

An Osprey hunting over the Baigup wetlands near Ascot in December 2020 caught either a Dusky Moorhen (*Gallinula tenebrosa*) or Purple Swamphen (*Porphyrio melanotus*) and took this back to the nest. It later returned to same wetland location to resume hunting (M. Clarke, pers. comm.).

Threats

Harassment by Australian Raven (*Corvus coronoides*) pose a threat to breeding success at most Perth sites. The Raven ties up the parent in chases, luring them away from the nest. They will physically touch the Osprey and they have even been observed pulling on tail feathers in flight (P. Burgess, pers. comm.) (Fig. 3). Out of the breeding season Osprey use nests as feeding stations, and Raven have been seen on them at Salter Point and Cottesloe where they have been scavenging.

Nesting sites are exposed, and adults have been observed on hot days standing over their young shading them with their wings. In 2019 there was a week of high temperatures that peaked at 41.6°C on 3 December; prolonged heat exposure may have been the reason a juvenile left its nest prematurely at Bentley and was found on the ground. Many nesting sites are in Norfolk Island pine trees which are in declining health. If this continues it may limit the availability of future nesting sites.

Figure 3. Osprey harassed aggressively by Australian Raven at Attadale, July 2019. Photo: Peter Burgess.

Osprey may drown if their fish prey is too large to lift from the water (Hollands 2003). An Osprey was observed swimming near the Narrows Bridge in 2017. It had caught a good size bream that was too large to lift out of the water. It used its wings in a butterfly stroke motion to swim ashore and covered quite a distance (D. Roberts, pers. comm.).

Human-made threats include suffocation of young in a nest by a plastic bag, and damage to talons by entanglement in fishing line. A young Osprey was shot near Crawley (Pelican Point) in 2017 (Swan Estuary Reserves Action Group Inc. 2017).

Discussion

Since 1980 Osprey have become increasingly common in Perth, with a breeding population established along the coast and on the banks of the Swan and Canning rivers (Tables 1, 2, Fig. 1). The shallow waters of the coast and estuaries have abundant prey species including Black Bream (*Acanthopagrus butcheri*), Common Blowfish (*Torquigener pleurogramma*), Sea Mullet (*Mugil cephalus*), Silver Trevally (*Pseudocaranx dentex*), Smalltooth Flounder (*Pseudorhombus jenynsii*), Western Striped Grunter or Trumpeter (*Helotes octolineatus*), Yellow-eyed Mullett (*Aldrichetta forster*), Yellowtail (or Bar-tailed) Flathead (*Platycephalus westraliae*) and Yellowtail Trumpeter (*Amniataba caudavittata*) (Stranger 2017; Singor 2020; M. O'Brien, pers. comm.).

This monitoring program of nesting sites has shown that all nests are close to the ocean or a river; the site furthest from water is at Bentley, 600 m from the Canning River (Fig. 1). Many successful nests are close to a bridge, e.g., the Garratt Road Bridge (Ascot site), Redcliffe Bridge (Ascot, Ron Courtney Island site), Narrows Bridge (Crawley, Old Swan Brewery site), Canning Bridge (Mount Pleasant site) and Mount Henry Bridge (Salter Point site). Osprey are often seen standing on bridge lamp posts which provide an ideal vantage point to hunt. The nests are close to shallow water, and/or channels where fish migrate up or down stream, facilitating fishing and bathing.

Nesting sites are usually high in trees or human-made structures with available perches, close to sites where nesting material can be obtained. Norfolk Island pines are frequently used (Tables 1, 2). They are high and the crown provides a flat base for the nest (Fig 2). However, large nests often tend to tilt or sag to a lower level after a few years which may be why they are not used continuously. A number of artificial nesting platforms have been installed, but only the one at Salter Point has been successful (Tables 1, 2). There is a growing interest from local councils in the installation of artificial nesting platforms (Singor 2019b); if these are strategically placed they may result in an increased Osprey breeding population.

During the monitoring program successful nests had one to two juveniles with the number of fledged young per successful nest being 1.4 (Table 2). This is the same as that reported by Holsworth (1965) from nine nesting attempts on Rottnest Island. In northern New South Wales (NSW), productivity was 1.6 young per pair per year from eight nests in the late 1980s (Clancy 1989) and 1.36 young per pair per year a decade later from 57 successful breeding attempts (Bischoff 2001). Whilst a pair monitored near Forster, NSW, over a 7-year period raised on average one fledgling per year (Rose 2000).

Banding has shown that juvenile Ospreys disperse after fledging; young birds banded on Rottnest Island have been recovered at Lancelin (112 km north), Wilson Inlet, Denmark (386 km south-east) and near Albany (425 km) (Holsworth 1965).

Sufficient baseline data has been collected to enable any future population trends to be monitored. The health of the Osprey population can act as an environmental indicator of the water quality of the Swan and Canning Rivers and the health of their fish stocks. They are thriving along the warmer east coast of Australia with populations growing quickly in Queensland and NSW in recent decades (Dennis & Clancy 2014). They now breed at least 800 km farther south along the coast of NSW than they did 20 years ago with a ten-fold increase in breeding pairs in this same period (Poole 2019; Dennis & Clancy 2014). It will be interesting to see if the Osprey population in WA follow these trends.

Acknowledgements

Acknowledgement goes to all the people who provided information and assisted in monitoring their Osprey sites: Janet Allen (Swan Estuary Reserves Action Group), Meir and Shelley Altman, Mavis Andrews (Co-Ordinator of Mount Henry Peninsula Conservation Group), John Baas,

Jon Bassett, Lee Beavis, Steve Bell, Robyn Benken, Peter Burgess, Richard and Lorraine Chyne, Mike Clarke, Graeme Clifton, John Darnell (Western Australian Museum), Rick Dawson, Marion and Peter Ewing, David Free, Ruth Greble, Claire Greenwell, Martin Greenwood, Geoffrey Groom, Julia Gross, Michael Hancock, Sue Harper, Art Hyde, Ron Johnstone (Western Australian Museum), Georgina Lambert, David Lawrence, Wynton Maddeford, Danny McCreadie, Mike Nichol, Margaret O'Brien, Catherine O'Neill, Paul Orange, Viv Read, Helen Reinhold, Darryl Roberts, Peter Rushton, Joseph Russell, Terry Scott, Gary Tate, Pam Thornton, Jan Hendrik van der Walt, and Pauline Woolley. The author would like to thank Margaret O'Brien for her valuable feedback on a previous version of this paper and contribution of additional information about Ospreys. Glenn Moore (Western Australian Museum) assisted in the identification of the fish species and Allan Burbidge, John Darnell, Elaine Davison and Paul Doughty provided constructive feedback to improve this manuscript.

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Obituary

Loisette Matilda Marsh AM

31 October 1928–21 May 2021

Early life

Born in 1928 in Victoria, B.C., Canada, the only child of Loise Ducker and William Notcutt Rutt, Loisette's relationship with the ocean began early in her childhood, spent on the shores of Mill Bay, Vancouver Island. Her father, William Notcutt Rutt, was a retired sea captain who wanted to remain close to the sea. He built and ran a guest house, *Kilmalu*, on their property which had its own private beach. Loisette was fascinated by all the amazing sea creatures that she could find at low tide, commenting "….I would amuse myself by fossicking along the rocky shoreline at Mill Bay. In the tidal pools, I would see little seashells, green anemones, colourful crabs, and purple sea stars clinging to the rocks. Spying interesting animals interacting with each other in the rock pools was an endless source of entertainment. The large purple sea stars clearly made an impression upon me."

Figure 1. Loisette Marsh. Photo: WA Museum.

Loisette was home schooled until she was nine then, in 1937, the family moved to England to run a guest house in Torquay, Devon. They moved again in 1938, to Western Australia, where they settled in Freshwater Bay. Loisette attended Methodist Ladies College, her school years spanning World War II (1939–1945). She was a talented student, generous in helping others, and was Dux in 1945. Her fondest memories were of her classmates, some of whom became lifelong friends, and of her Biology teacher, Mrs Nicholas, who guided her along the biology path.

It was inevitable that Loisette would study biology at the University of WA, where she graduated with an Honours degree in Zoology. Dr Ernest Hodgkin then became her supervisor and mentor during subsequent postgraduate work. In 1956, after research on the fauna of intertidal rock platforms at Rottnest Island, she obtained a Master of Arts in Zoology. Loisette then married and departed Australian shores to live on Norfolk Island (1960) and later Fiji (1963), whilst also raising her two children, Jennifer and Peter.

It was at this time that she began scuba diving. Her first dive was in late December 1957, in Cockburn Sound, with a dodgy regulator, and lasted 10 minutes. She joined the USFA (Underwater Skindivers and Fishermans Association), and gained a lot of diving skills, however, she was horrified by the wholesale decimation of the fish populations wherever competitions were held.

WA Museum career

The family returned to Perth in 1968, and this is when Loisette's career began in earnest, initially as a Demonstrator in the Zoology Department, University of WA. Dr Hodgkin had always encouraged Loisette to continue her marine research and, in 1970, she was thrilled when offered the chance to work at the WA Museum, at a time when the Museum was expanding from a small museum to a large, multidisciplinary organisation. Starting as a Graduate Assistant in the Mollusc Department, Loisette quickly became Curator of Marine Invertebrates (1972–1978) and later Head of Marine Invertebrate Zoology (1978–1993), now the Department of Aquatic Zoology.

During her illustrious career, Loisette participated in many field trips and biological expeditions. She scuba-dived, snorkelled and reef-walked on coral reefs along the entire WA coast, from the Houtman Abrolhos to the Kimberley and the offshore atolls (Rowley Shoals, Scott and Ashmore Reefs), as well as in many amazing, far flung places around world, such as Christmas and Cocos (Keeling) Islands, Indonesia, Malaysia, Mauritius, Fiji, the Tuamoto Archipelago and many more. She was also invited to participate in many international expeditions (e.g. Indonesian *Rhumphius* expeditions to the Moluccas in eastern Indonesia) and dived in many places where no-one had dived before, saying that it was "magical to be able to do these things and get paid for it!"

At the WA Museum, Loisette took part in the Crown of Thorns study at Kendrew Island in the Dampier Archipelago (1972–74). As this large sea star preys upon hard corals, the work also provided an opportunity for major additions to the Museum coral collection. The survey occurred three times a year for three years, with the WA Museum party camping on the remote, minute (11 hectares) Kendrew Island. The party consisted of three men and one woman as, due to the large tides, the aluminium dinghy had to be lifted on to a rock shelf when not in use, and it took three strong men to do so. Consequently, Loisette and colleague Shirley Slack-Smith alternated on trips. Loisette commented that conditions were sometimes extreme (up to 44˚C in the tent in February), humidity was high and the sandflies were intolerable, plus freshwater was always short. However, they ate well, oysters, excellent fish, rock lobsters – a compensatory seafood feast!

Loisette made further coral collections during fieldwork to the Houtman Abrolhos Islands (1976 North Island and Pelsaert Group) and further faunal survey work in the Dampier Archipelago (1978) enabled her to sample many inshore habitats not previously covered. In 1979, she collected corals from South Passage, Shark Bay and at several localities on the east side of Dirk Hartog Island, including Sunday Island and Egg Island.

Figure 2. Loisette in her office in the former Francis Street building of the WA Museum. Photo: WA Museum.

A series of WA Museum field trips in 1977, 1978, 1980 and 1981, some in conjunction with the WA National Parks Authority, were made to the Ningaloo Reefs, resulting in the first extensive coral collections of this region. With Shirley Slack-Smith, Loisette also made collections in Shark Bay (1981) and along the coastline between Perth and Port Gregory (1983). The Houtman Abrolhos Islands were also sampled in 1983.

In 1984, Loisette participated in the final expedition of the CSIRO research ship *Soela* to the NW Shelf, between Port Hedland and NW of Cape Leveque, in areas previously unexplored. Numerous specimens were collected, many previously unrecorded from Australia or WA waters. She also participated in WA Museum faunal surveys, making collections from the shelf-edge atolls off the north-west coast, from the Rowley Shoals (1982), Scott and Seringapatam Reefs (1984), to the remote Cartier Reef and islands of Ashmore Reef (1986).

During these active periods of fieldwork, the taxonomy and distribution of corals were Loisette's main focus. Consequently, the Museum's holdings increased from a few coral species on a shelf to a vast, comprehensive collection. Additionally, she also preserved and curated all the numerous marine invertebrate specimens that she had also collected

during her many expeditions, as well as hand documenting their details in the vast Museum registers. There are now thousands of specimens in the WA Museum Marine Invertebrate collections, and more widely in the Aquatic Zoology collections, attributed to Loisette, which are held in perpetuity on behalf of the State - and all of this was done while successfully rearing her children!

Throughout her career, Loisette also meticulously documented the findings and field notes from her various expeditions and trips in her notebooks. These field notebooks are now held in the WA Museum Library and available for academic and public use. All these experiences led to Loisette having a vast, detailed appreciation and knowledge of our vast coastline and beyond. Over the span of her career, the WA Museum has benefited from the numerous respected Australian and international scientists who personally visited her, and from the numerous students at undergraduate and post-graduate levels who she mentored, and who held her in such awe.

Loisette retired from the WA Museum in 1993. As well as her coral expertise, she was one of only two scientists in Australia specialising in the taxonomy of echinoderms (marine invertebrates that include sea stars, brittle stars, sea cucumbers, sea urchins, sand dollars and crinoids). After retirement, she continued as a Research Associate of the Museum, working on echinoderms in particular. On *World Oceans Day*, 2020, at the grand age of 90, Loisette launched her *magnum opus*, a comprehensive book on her beloved sea stars, co-authored with Dr Jane Fromont, entitled *Field Guide to the Seastars of Australia*. Loisette is quoted as saying "It has taken a lot of perseverance to bring this book to its completion. After my retirement from the WA Museum in 1993, I began writing the book in earnest. I was hoping to have the book published much sooner, but the advancement in genetics meant the taxonomic placement of many species had to be revised."

A pioneering woman in science

Today it is pertinent to be reminded how far women marine scientists, in particular, have progressed. Prior to the 1960s, women were not permitted on research vessels, and thus could only study shallow water fauna, close to the coastline. This only changed in 1963, when the Scripps Institution of Oceanography, USA, invited a woman to participate in a marine expedition. Loisette commented "This change made it possible for me and my female colleagues to further our careers in marine biology."

There were some occasions, however, when 'life on board' was less than comfortable. In 1976, on MV *Sprightly* dredging off Dongara, Loisette and Shirley shared a cabin that had been newly painted for the occasion. The sea was very rough and the motion of the ship plus the smell of new paint was not a good combination. Also, the 'laboratory' was a bay on the deck where water sloshed around their feet and they had to wedge themselves in, resulting in bruised rears. When the weather was better, they sat on deck to sort the haul, but it was covered with sponge spicules and so it was all a rather painful experience! On another occasion, in December 1979, aboard the CSIRO *Soela* exploring the NW Shelf, the air conditioning

Figure 3. Loisette Marsh in 1994 holding the staghorn coral *Acropora loisetteae*. Photo: WA Museum.

broke down, and the bedding of their bunks was permanently soaked as the porthole leaked. Again, they had the smell of new paint to contend with as well as the heavily rolling ship, but Loisette commented that the exciting catches, including *Nautilus* and many rare molluscs and echinoderms, compensated for any discomforts.

A fieldtrip in 1992 was also memorable for different reasons. Loisette, accompanied by Shirley Slack-Smith and Tim Meagher, travelled to Sabah in the northern portion of Borneo, diving off the east coast to assess coral reefs for the regional National Parks authority. They nervously noted a pearl farm with armed guards on the watchtowers as, beyond these islands, the waters were considered unsafe due to their proximity to the Philippines. Consequently, National Parks sent an armed guard out with them for protection. However, Loisette reported that they were more scared of the guard's machine gun, and of the local fishermen using dynamite to catch fish

whilst the team was diving, than any potential pirates!

Loisette's work has played a major role in the conservation of our marine heritage, and has been essential to the design and designation of marine parks and reserves around the WA coastline. Her knowledge and documentation of the corals and echinoderms of the Ningaloo Reef played an important role in the designation of the Ningaloo Marine Park (May 1987) and she was active in the protection of the Cottesloe reef, which was implemented in 2001.

Loisette was a well-respected, long-term member of the WA Naturalists' Club, passing on her amazing knowledge and inspiring young and old and alike. She was also a champion of education, leading beach walks and encouraging young people and interested adults to appreciate and conserve the sea, the seashore and the animals found there, for both the WA Naturalists Club and the WA Museum.

In 2021, Loisette's accomplishments were recognised in the Queen's Birthday 2021 Honours List by the award of Member (AM) in the General Division of the Order of Australia for significant service to marine science and zoology, which was awarded posthumously on 7 September 2021.

Loisette's family, friends and colleagues are incredibly proud of her many achievements. She will be remembered as a remarkable, much respected and internationally acclaimed scientist, as well as a genuine pioneer in her field with a ubiquitous knowledge. Her works, meticulously documented in her many scientific publications and field notebooks, are a vast and significant contribution to science, demonstrating her detailed research and unrivalled knowledge, appreciation and understanding of WA's massive coastline and invertebrate fauna. When I arrived at the Museum, this amazing, pioneering woman most generously mentored me, passing on her ubiquitous knowledge, supporting and gently steering me to find my way forward. I have much to thank her for.

Over her distinguished career, Loisette published numerous scientific papers, articles and books (see Appendix 1). The book *Field Guide to Sea Stingers and other Venomous and Poisonous Marine Invertebrates of Western Australia*, co-authored with Shirley Slack-Smith, received a prestigious Whitley Award in 2010. This award recognises outstanding publications dealing with the promotion and conservation of Australasian fauna.

Loisette Marsh's contributions to the specimens in the WA Museum

Loisette has collected a total of **9264** registered specimens from **9 Phyla** (many more remain unregistered). This includes a total of **163 type specimens.**

She has collected specimens from the following Phyla: Brachipoda (26), Bryozoa (88), Chordata (137), Cnidaria (5,414), Ctenophora (2), Echinodermata (3,137), Hemichordata (12), Porifera (280) and Protozoa (1).

Her contribution to marine science has also been acknowledged through 13 taxa (1 genus and 12 species) having been named after her:

Zoanthus marshae Carlgren, 1954 (zoanthid)

Coscinaraea marshae Wells, 1962 (hard coral)

Runcina marshae Burn, 1966 (mollusc)

Loisettea Rowe & Pawson, 1985 (genus of sea cucumbers)

Stylabates loisetteae Fautin, 1987 (sea anemone, found on shells of deep-water hermit crabs)

Stylaster marshae Cairns, 1988 (hydroid)

Cymbastela marshae Hooper & Bergquist, 1992 (cup sponge)

Acropora loisetteae Wallace, 1994 (staghorn coral)

Laevidentalium marshae Lamprell & Healy, 1998 (scaphopod mollusc)

Dipsastraea marshae Veron, 2000 (moon coral)

Aquilonastra marshae O'Loughlin, 2004 (seastar)

Circeaster loisetteae Mah, 2006 (seastar)

Psolidium marshae O'Loughlin & Maric, 2008 (sea cucumber)

And here I will let Loisette have the last word… "To be remembered as a sea cucumber is questionable,"; "I guess not many people can say they have a genus of sea cucumber named after them, as well as several marine invertebrate species. The sea cucumber is not the prettiest animal; it's all red and spiky. I much prefer the seastar and I am lucky to have one from the Red Sea named after me".

Exerts from OA Citation by DJ

I too, personally, have much to thank Loisette for. When I arrived at the Museum, in 1977, as a part-time Research Assistant (and a single mother with two small children), there were only two female scientists, Loisette and Shirley Slack-Smith. I was lucky enough to be in an office next door to Loisette's. These two amazing, pioneering women most generously mentored me, generously passing on their ubiquitous knowledge, and gently steering me to find my way. These two women remain unsung heroes, yet they still generously encourage me, without rancour, to reach heights that I never dreamed of attaining. I have much to thank them for.

Today, Loisette is a much-respected scientist, with a world-wide reputation and is regarded as a genuine pioneer, with a ubiquitous knowledge. Her work, meticulously documented in many scientific papers and her field notebooks, has led to a vast, detailed appreciation and knowledge of our enormous coastline, and beyond, and has been essential to the design and designation of marine parks and reserves around the WA coastline.

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Appendix 1

Loisette Marsh Publication List

1972–1982. Field notebooks, Nos 1-16 (WA Museum Library).

Covering the Fremantle area, Kendrew Island, Dampier Archipelago, Crown of Thorns Survey 1972–74, Abrolhos Island, Guam, Indonesia, Europe, Torres Strait, North-West Cape, New Guinea, *Rumphius* Expedition and other places.

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From Field and Study

Observations of successive crops of an individual *Myxarium nucleatum* (a jelly fungus) in Western Australia

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A rare opportunity to observe *in situ* successive crops of fruit bodies produced by an individual fungus over several fruiting seasons has enabled scrutiny of a key diagnostic feature used for field identification of the Crystal Brain Fungus - *Myxarium nucleatum* Wallr.

Myxarium nucleatum is typical of a jelly fungus as it produces gelatinous fruit bodies on rotting wood. Also typically, its convoluted-lobed (cerebriform) fruit bodies rapidly expand during rainfall and then shrivel up almost immediately after the rain ceases. Few jelly fungi can be confidently identified to species level in the field, and microscopic features usually need to be analysed to determine their identity, however, in the case of *M. nucleatum*, many fungal field guides advise that it can be readily and reliably identified with the naked eye or with a hand lens, by observing opaque white mineral inclusions embedded in its semi-translucent fruit bodies. Less convincingly, some field guides and scientific descriptions comment that inclusions may not always be visible, e.g. "inclusions often visible" (Roberts 2001, p. 134).

To date only two collections of *M. nucleatum* have been confirmed from Western Australia. The first collection, in 2009 from John Forrest National Park, Mundaring (PERTH 08473714) observed and collected at a single point in time, did not display any conspicuous white inclusions in its fruit bodies. The second collection also lacked visible inclusions when it produced several of its first observed crops of fruit bodies. This collection was from a suburban garden in Perth in 2019 (PERTH 09178546), first observed and collected on 15 June 2019, fruiting on a dead water-soaked *Wisteria* branch about 2 × 40 cm. Daily observations thereafter showed that this fungus produced about 15 more crops in the same position on the branch in response to sporadic rainfall events from mid-June to early September 2019. In the following two years it produced several more crops from June to August 2020/2021. Each successive crop responded particularly well to rainfall rain at night, often transforming from being invisible to the eye pre-rain at dusk to displaying its fully expanded, convoluted lobes post-rain at dawn. The lobes of each crop would start to shrivel almost immediately after each rain event ended. Within a few hours they had contracted down to a remnant filmy patch of gelatinous slime on the wood. After a day or two of dry weather

Figure 1. An early-season crop of *Myxarium nucleatum* (PERTH 09178546) with almost all lobes lacking conspicuous white inclusions (fingernail shown for scale). **Figure 2.** A subsequent crop of *Myxarium nucleatum* fruiting later in the season on the same piece of wood, displaying conspicuous white inclusions in many of the lobes. **Figure 3.** A closer view of the white inclusions in one of the lobes of *Myxarium nucleatum* shown at bottom right in Fig. 2. **Figure 4.** Inclusions stranded as white lumps (each about 0.5 mm wide) after a crop of *Myxarium nucleatum* fruit bodies had contracted down to a filmy patch of gelatinous slime.

virtually no visible evidence usually remained of the fruit bodies. The fungus would fruit again at the same position on the wood when the next rainfall event occurred. As the season progressed the fruit bodies became noticeably less expansive after rainfall.

Mineral inclusions were not visible in most of the fruit bodies observed among the first few crops (Fig. 1). However, later in the season in July and August, crops of fruit bodies displayed 1–10 well-developed conspicuous white ellipsoid to irregular-shaped inclusions (each up to about 0.5 mm wide) in each of some of their lobes (Figs 2, 3). By September, as rainfall events were becoming rarer and crops of fruit bodies less expansive, inclusions were present in almost all lobes, and abundant inclusions persisted as white lumps stranded upon remnant filmy slime patches or seated directly on the wood surface (Fig. 4). The possibility that the deposited inclusions may be composed of calcium carbonate was tested by applying vinegar to them. However, no reaction occurred, suggesting they are not of such composition.

The observations outlined above on local representatives of *M. nucleatum* affirm the contention by some field guides that mineral inclusions are not always a reliable diagnostic feature of this species. This apparent inconsistency may be particularly pertinent when identifying an individual of that species observed or collected at a single point in time, which is the typical circumstance for how macrofungi are observed and collected. The observations suggest that an individual of *M. nucleatum* may be capable of producing many successive crops of fruit bodies, but easily visible mineral inclusions are not necessarily produced over time by all its crops. The observations show, at least in one local individual, that inclusions may be more prevalent in crops of fruit bodies produced by *M. nucleatum* later in the fruiting season.

It is possible that at least some of the many collections lodged in the Western Australian Herbarium currently identified as *Exidia* sp. or *Exidia glandulosa* may be *M. nucleatum*. However, determination of their status and the validity of the locally accepted current concept of *M. nucleatum* awaits detailed studies of their morphology and DNA sequences. The data from local collections needs to be assessed in relation to comparative data from elsewhere in the world, particularly data from recent phylogenetic studies which have revealed that the generally accepted concept of *M. nucleatum* in the northern hemisphere covers more than a single species (Spirin *et al.* 2017). For example, those studies report that one of the look-alike species - *Myxacium hyalinum* (Pers.) Donk - produces abundant mineral inclusions in coalescent fruit bodies at the end of the growing season and may have deeper-coloured fruit bodies and larger spores than *M. nucleatum*.

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From Field and Study

Opening Pandora's Box: *Pandorea* (Bignoniaceae) in Western Australia

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The genus *Pandorea* in Western Australia provides an interesting case study of the issues and consequences of transporting widespread native species between states.

Pandorea (Bignoniaceae) is a small genus of 10 species of woody vines and creeping shrubs found in Indonesia, New Guinea, Solomon Islands, Vanuatu and New Caledonia. When the genus was revised by van Steenis (1977), the diversity of the genus was centred on areas to the north of Australia. Continuing taxonomic studies mainly in Queensland, have shown that the broad species concept of van Steenis (1977), who recorded six species in the entire genus, needs considerable revision. There are currently eight recognised species in Australia (Australian Plant Census, 2013–): *P. baileyana* (Queensland, New South Wales), *P. floribunda* (Queensland, New South Wales), *P. doratoxylon* (Western Australia, Northern Territory, Queensland, New South Wales, South Australia), *P. jasminoides* (Queensland, New South Wales), *P. linearis* (Queensland), *P. nervosa* (Queensland), *P. pandorana* (all States, Indonesia, New Guinea, Solomon Islands, Vanuatu, New Caledonia) and *Pandorea* sp. Mt Maroon (Forster 7111, Queensland). Diversity of the genus *Pandorea* is now centred in tropical Australia.

All members of the family in Australia have flowers that are insect pollinated, either by nectar/pollen collecting bees, as well as wasps and flies. James (1992) noted that cultivated *P. pandorana* and *P. jasminoides* were protogynous, unable to self-pollinate and were self-incompatible (pollen tubes grow down the style and the into ovary but no fruit set results) when pollinated by the flower's own pollen. However, members of the genus cultivated at Kings Park were observed to be readily visited by honeybees and were partially self-fertile, suggesting that late onset incompatibility is readily lost in cultivation. James (1992) suggested although self-pollination resulted in much lower fruit set (about 2–4%), wild and feral populations appear to set a mixture of self and cross-pollinated seeds. With the rampant vegetative growth of both species (Fig. 1), spreading by seed may not be a major barrier to naturalisation, but it may reduce re-invasion after removal.

Figure 1. A large population of *Pandorea pandorana* in a creek in Mundy Regional Park. Photo: Greg Keighery.

Native populations of *Pandorea* in Western Australia are currently considered part of the highly variable *P. pandorana* as defined by van Steenis (1977). This species contains many variants and at least three subspecies: subspecies *timorensis* from Timor; subspecies *austrocaledonica* from Lord Howe Island, Vanuatu and New Caledonia; and all other populations including those in Australia are subspecies *pandorana*. Typically *P. pandorana* subspecies *pandorana* is a woody scrambler or vine with 5–9, ovate leaflets that are 2.5–8 cm long and 2–4 cm wide.

The Western Australian records of *P. pandorana* subspecies *pandorana* (Western Australian Herbarium, 1998–) are a series of highly disjunct populations on rocky sites in the south-eastern Kimberley, Pilbara and the central desert ranges. Plants from these regions differ in leaf morphology as outlined below.

South-eastern Kimberley

These populations are woody vines that have 5–9 leaflets that are narrow lanceolate, 3–5 cm long, 1–2 cm wide. They correspond to similar plants from the Northern Territory and the dry rainforests of Queensland that have been segregated as *Tecoma meonantha* (*Tecoma* is a genus closely related to *Pandorea*). However, they are reported to intergrade into *P. pandorea* outside of Western Australia and included in the widespread *P. pandorana* (van Steenis (1977).

Pilbara and the central desert ranges

These populations are erect shrubs and have 5–9 linear leaflets that are 0.2–0.5 cm wide. The erect branches are used as spears by aboriginal people. These have been recognised as *P. doratoxylon*, but were combined under the extremely variable *P. pandorana* by van Steenis (1977). Currently this species is recognised in the National Australian Plant Census and Queensland, but not in Western Australia (Western Australian Herbarium 1998–), South Australia, New South Wales or Victoria. Most authorities note that plants from arid regions of their states differ from those of wetter areas, but there is some integration in eastern Australia. We consider that *P. doratoxylon* (Western Wonga Vine, Fig. 2) should be re-instated for the desert populations (this paper).

Over the past decade our surveys in remnant bushland in the south-west of Western Australia has shown that *Pandorea pandorana* (Wonga Vine, Fig. 2) and *P. jasminoides* (Bower of Beauty Vine, Fig. 3) are establishing naturalised populations (this paper). *Pandorea pandorana* was first recorded in 2008 seeding into a linear remnant near Donnybrook. Since then, populations have been recorded from bushland: near Margaret River; in Hamel; and very large populations in creeks in Mundy Regional Park and other sites in the Perth Hills, where they produce copious seeds and seedlings (Peter Day, pers. comm.). *Pandorea pandorana* is also recorded

Figure 2. A branch of *Pandorea pandorana* flowers, Uluru April 2013. Note the cream flowers with purple spots in the throat. Photo: Bronwen Keighery.

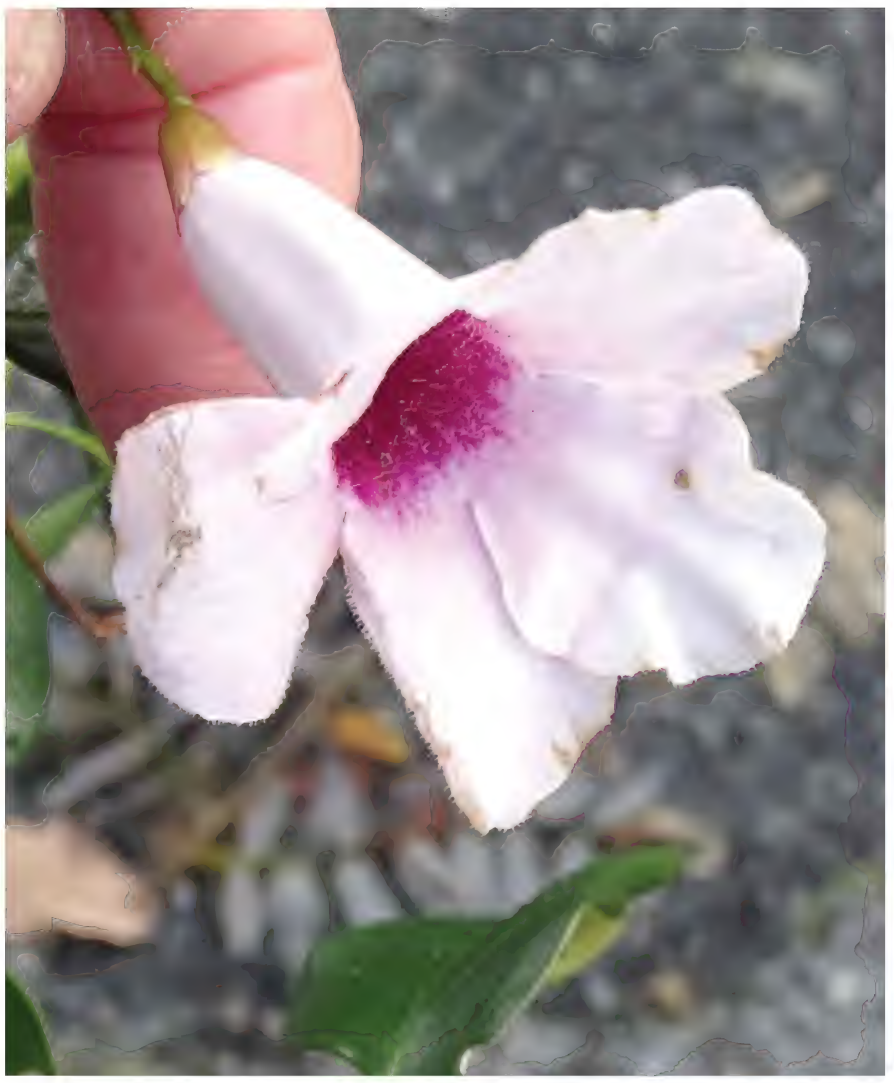

Figure 3. *Pandorea jasminoides* flower with its deep pink throat and spreading lobes. Photo Bronwen Keighery.

as a weed in New Zealand (Owen 1996). Naturalised populations are also recorded within the range of the species in Victoria and South Australia (Jeanes 1999).

A population of *P. jasminoides* was recorded in Mundy Regional Park in 2020. It is native to Queensland and New South Wales, but was recorded as a garden escape by Willis (1972) in Victoria (an observation that largely went unnoticed). This is an extremely vigorous climber to 8 m and easily tops trees along the creekline where it occurs. Both species have multiple cultivars in cultivation and at least two of *P. pandorana* (cv Ruby Belle and Alba) are naturalising in Western Australia.

Both species set fruits that contain very large numbers of papery wind dispersed seeds and already are currently very serious weeds of creeks along the Darling Scarp. They may invade urban reserves of the Perth Hills and many bushland sites in the lower south-west, if not controlled. Both native forms, whatever names apply, do not correspond closely to the weedy plants of *Pandorea* spreading from cultivated material which originates from eastern Australia. These plants far outside their native ranges should not be considered as part of a native species for Western Australia. Current perceptions that these are "native" plants based on very broad species concepts hinders the management of these weeds. Perhaps we could follow the British (Clement & Foster 1994) who would list the weed as *Pandorea* "Wonga Vine" or as *Pandorea pandorana* **alien variants** to clearly distinguish the weed.

A co-ordinated plan to remove plants from bushland, clear warnings on nursery plants (Wonga Vines have been promoted in the past as native substitutes for exotic vines, such as *Thunbergia alata*) and their availability is needed to prevent these species spreading further. Fortunately, these weeds pose little risk to our native Western and Kimberley Wonga Vines as they are currently in very different regions.

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Book review

A Field Guide to the Flora of the Tarin Rock Reserves, with supporting information on fauna and fungi

By Jolanda Keeble. *Self-published 2021.*
ISBN: 978-0-9945554-7-2, $40

This book will be a very valuable resource for any nature lover travelling in the southern wheatbelt area of Western Australia. It contains names and photos of 589 plants as well as the names of some common reptiles, frogs, mammals, birds and insects of the area. The Tarin Rock Reserves are located between Dumbleyung and Lake Grace, Western Australia.

The surveys were carried out over a period of three years and cover all months of the year.

Given that over 80% of the wheatbelt is agricultural land and mostly cleared of native vegetation it is excellent to have a record of the plants that remain in the area. The Tarin Rock Reserves cover an area of 2367 hectares and are managed by the Department of Biodiversity, Conservation and Attractions.

The book also contains descriptions of the geology, hydrology and physical characteristics of the area as well as some interesting notes on the Aboriginal heritage there. There are numerous informative maps.

The book is well set out and the photos are clear and informative. Firstly, there is a monthly flowering calendar with photos of each plant genus ordered by flower colour. Then in the native flora section the plants are ordered by genus in alphabetical order. Where possible, photos of both the habit and a close-up of flowers and leaves have been provided with descriptive text underneath the photos. Scientific names are given and also common names if they have them.

It would be difficult to carry this book in your pocket but would be easy to have in the car especially as it has a sturdy construction. A visit to an area is always more fulfilling if you know what you are seeing. You would certainly pack this book when travelling there as it would be an invaluable source of information.

Jonica and Peter Foss

Erratum

Images on the front cover of 31(2), May 25, 2018, are Whistling Kite, not Swamp Harrier. The editors thank Stephen Debus, University of New England, for drawing this to their attention.

CLUB NEWS

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